



Figure 4. Seasonal Isotherms of Sunfish Lake.



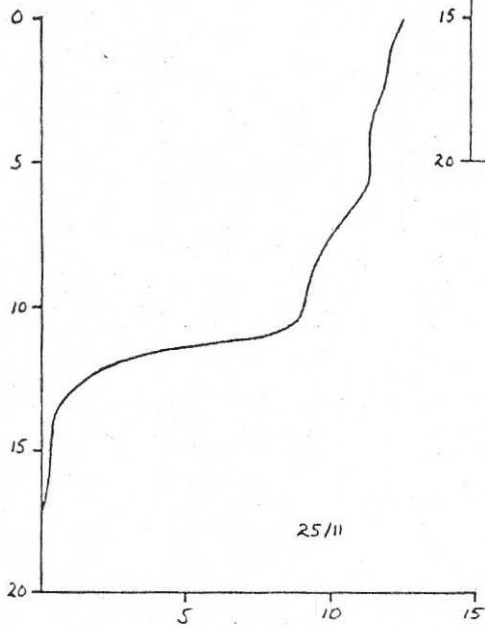
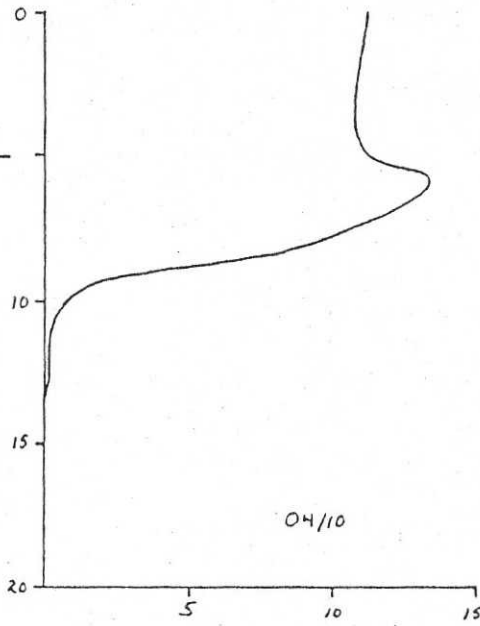
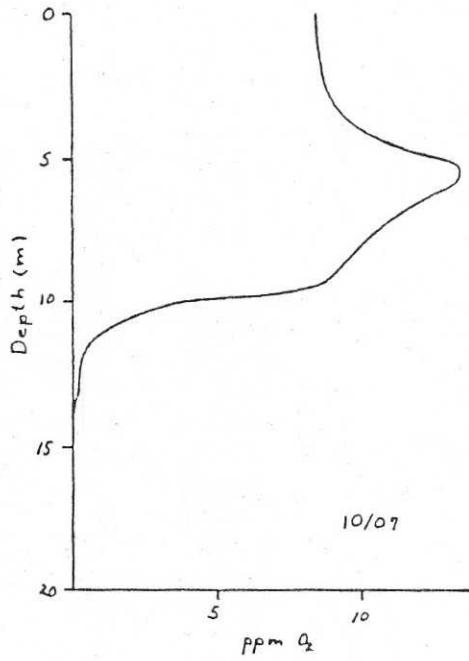


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C

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Figure 5. Dissolved Oxygen Profiles for Sunfish Lake.



1. The first part of the report is a general introduction to the subject.

2. The second part is a detailed description of the methods used.

3. The third part is a discussion of the results.

4. The fourth part is a conclusion.

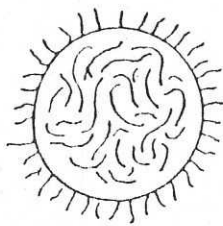
5. The fifth part is a list of references.

Figure 6. Sketches of 3 temporarily unidentified algae of
Sunfish Lake.

A. Sun

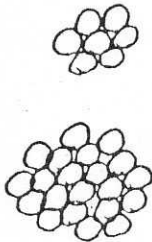
B. R.S.

C. Lenores



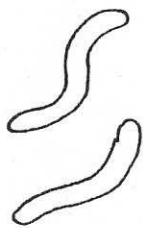
22 μ m.

A. Sun



8.5 μ m

B. R.S.



5.0 μ m.

C. Lenores



METHODS AND MATERIALS

Sunfish Lake was sampled weekly from the third week in July until the end of August and then once in early October and again in late November following overturn. An additional zooplankton sample was collected in the first week of July. Phytoplankton and zooplankton samples were collected at the deep end of the lake where the water depth was 20 metres (figure 1), and were always collected between 1100 - 1500 hours.

Zooplankton samples were collected with a 22.4 l. Schindler trap and were obtained from the lake surface to the bottom at one metre intervals. A 40% formaldehyde-5% sucrose solution was used to preserve the zooplankton for laboratory analysis.

Phytoplankton samples were collected by obtaining whole water samples using a 1.5 l plastic VanDorn sampler. Samples were taken at 1 metre intervals from the surface to a depth of 1 $\frac{1}{4}$ m and at $\frac{1}{2}$ m intervals from depths of 6 to 10 m where the *Oscillatoria* layer is concentrated. The plankton samples were transferred to 300 ml bottles, fixed immediately with a 1% Lugols Iodine solution and stored for laboratory analysis.

The phytoplankton were identified and enumerated using a Wild (Heerbrugg) inverted microscope. Identifications were made at a magnification of 400 x using the Upsalla Fytoplankton key and enumerations were made at a magnification of 200 x. Each sample was thoroughly but gently mixed by inversion and subsampled by pipetting from top to

THEORY OF THE EARTH

The theory of the earth is a branch of geology which deals with the origin and development of the earth and its various parts. It is a science which seeks to explain the processes which have shaped the earth and its features. The theory of the earth is based on the study of the earth's history and its various parts. It is a science which seeks to explain the processes which have shaped the earth and its features.

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bottom to enhance the integration. Samples were diluted to $\frac{1}{2}$ concentration and allowed to settle for no less than eight hours in a 50 ml settling chamber. Enough cells were counted in total for each sample for a $\pm 20\%$ accuracy according to Lund's (1958) criteria.

The average cell volume of each algal species cell, filament or colony was obtained from Munro (1978), or was calculated using an optical micrometer, in order to present the data in units of biomass.

Three algal species could not be identified and were termed Suns, Lenores, and R.S. Sketches of these alga are presented in figure 6.

Zooplankton samples were identified at a magnification of $64\times$ and enumerated at $25\times$ using a Wild dissecting microscope and a petri dish with a grid bottom. The entire concentrated sample from the Schindler trap was enumerated with the same degree of error as was present in the phytoplankton counts ($\pm 20\%$). The samples were diluted only when algae concentrations were sufficient to impede the zooplankton counting.

Dissolved oxygen was measured in the field using a Y.S.I. combination oxygen-temperature meter and probe on the October and November sampling dates. As well, one oxygen profile was obtained early in July before any plankton samples were obtained. Specific conductivity was measured with a Beckman conductivity meter and probe on the November sampling date. An annual CaCO_3 profile compiled by Duthie and Carter (1970) is used to aid in locating the position of the chemocline.

Temperature profiles were recorded by Mr. J. Hutchison, a cottage owner on Sunfish Lake, using a thermistor on a weekly basis throughout the entire sampling period.

Zooplankton Identification

Copepoda

Members of the order Copepoda were classified to suborder using a key developed by Wilson and Yeatman (1959). The two major suborders found can be distinguished by the following characteristics:

Calanoid	Cyclopoid
First Antennae: reach from near end of metasome to near end of caudal setae.	reach from proximal third of cephalic segment to end of metasome.
Caudal Setae: of equal or unequal length	of unequal length
Egg Sac: one sac carried medially	two sacs carried laterally
General Body Shape: see figure 7 (a,b).	

In addition to identifying and enumerating each of the copepod orders, the number of calanoids bearing egg sacs as well as the number of eggs per sac was recorded. Because the egg sac tends to remain intact when separated from the female in preserved samples, it was not necessary for the egg sac to be attached. Complete egg sacs of cyclopoids were recorded, as individual eggs within the sacs were not distinct enough to be counted accurately.

Rotifera

The class Rotifera was broken down to species using a key prepared by Edmondson (1959). Four major species, displayed in figure 8 (a,b,c,d) and five trace species were discovered.

The two *Kellicoa* species found, *K. bostoniensis* and *K. longispina* can be distinguished on the basis of their anterior spines. *K. bostoniensis* has one long spine and three small ones, whereas, *K. longispina* has one long spine, two moderate sized spines and three minute spines.

Filina longiseta has a very simple, easily recognized body plan. The body is oval, with two long anterior spines whose origins are very close together, and one long posterior spine.

Keratella quadrata, not as common as the previous three species, but is significant enough to be considered the fourth major rotifer. Its shape is unique and easily recognized. The body resembles a stout rectangle, with four small anterior spines of equal length. The two posterior spines are longer than the anterior ones.

Cladocera

The order Cladocera is dominated in Sunfish Lake population by three species from the genus *Daphnia*; *D. rosea*, *D. pulex*, and *D. schoedleri*. The features used to identify the *Daphnia*, taken from Torke (1974), is schematically displayed in figure 9. Key features, distinguishing the three species, as described by Brooks (1959) and Brandlova et al (1972), are shown in figure 10 (a,b, and c).

D. rosea is somewhat more variable in morphological characteristics than the two other daphnid species. This species usually has no crest, however when present, the crest is less than 0.1 mm. The optic vesicle is situated close to the anterioventral margin. The tail spine is slender and short, between 1/3 to 2/3 the length of the valve. The valve itself is broad, the width being approximately 3/4 of the length. The anal spines of the postabdomen number between 12 and 15 with the first spine (one closest to the postabdominal claw) slightly enlarged and bulbous at the spines base. The claw itself has no spines. *D. rosea* is considered to be one of the larger daphnids, ranging in length from 1.2 - 2.0 mm.

D. pulex, the largest species found in Sunfish Lake, ranges from 1.5 to 3.5 mm in length. No crest is displayed and the optic vesicle is situated in the extreme anterioventral corner of the head. It is a very broad species, in which the width of the valve is often equal to the length. The shell spine is always short and stout.

D. schoedleri, like *D. rosea* is a moderately large species; ranging from 1.2 to 2.0 mm in length. The shell spine is thick, and is about 1/2 the length of the valve. Arising posteriodorsally from the valve, the shell spine and dorsal valve edge form a very straight unit, characteristic of Sunfish Lake specimens. The crest is small but fairly consistent in size and shape. *D. schoedleri* is not as broad as the other two previously mentioned species. The valve width is usually 1/2 that of the length.

Figure 1. Location of the study area in the State of Georgia.

a) Study area location

b) Study area map

c) Study area map

d) Study area map

Figure 2. Map of the study area showing the location of the study area in the State of Georgia.

Figure 3. Map of the study area showing the location of the study area in the State of Georgia.

Figure 4. Map of the study area showing the location of the study area in the State of Georgia.

Figure 8. Sketches of the four dominant Rotifers of Sunfish Lake

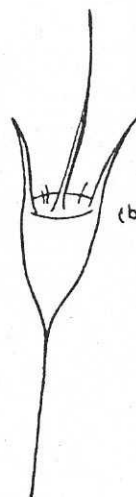
- a) *Kellicottia bostoniensis*
- b) *K. longispina*
- c) *Filina longiseta*
- d) *Keratella quadrata*

Figure 7. Sketches of the two suborders of Copepoda found in Sunfish Lake.

- a) Calanoid
- b) Cyclopoid



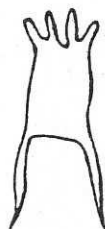
(a) K. bostoniensis
150x



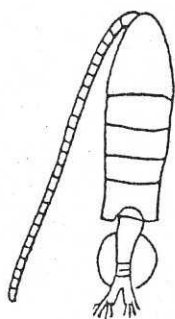
(b) K. longispina
150x



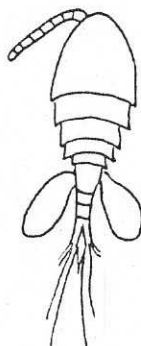
(c) F. longiseta
300x



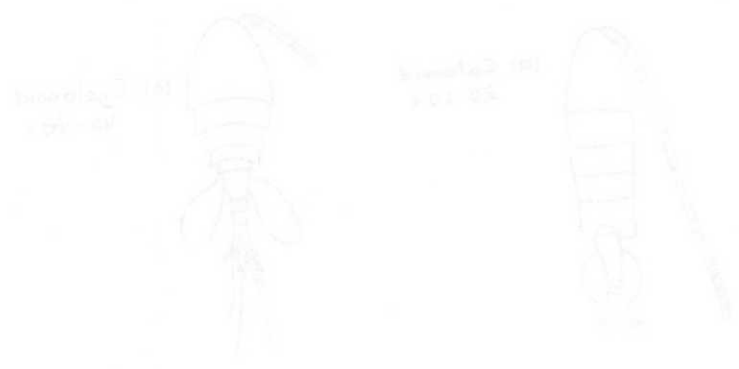
(d) K. quadrata
150x



(a) Calanoid
20-60x

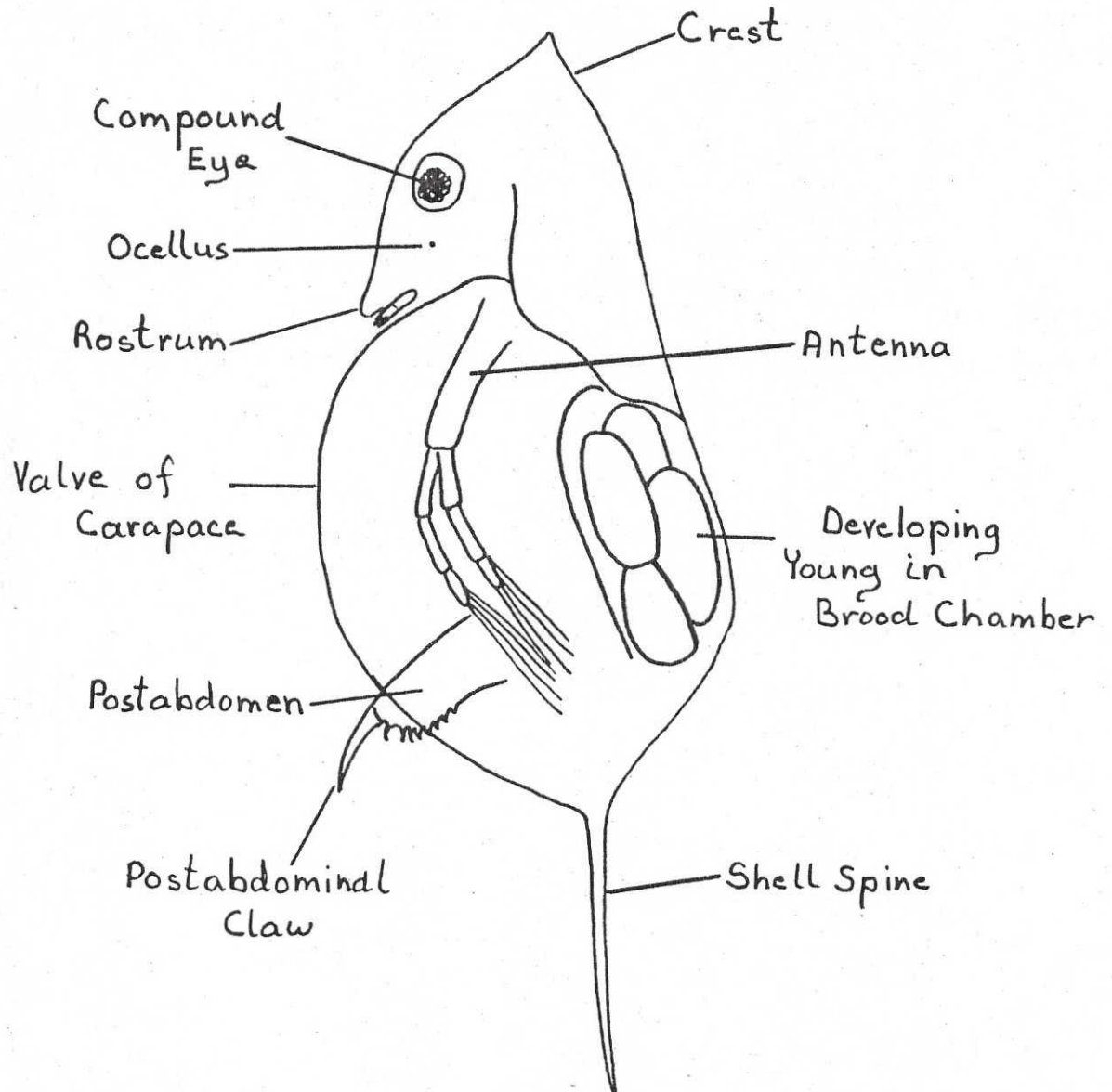


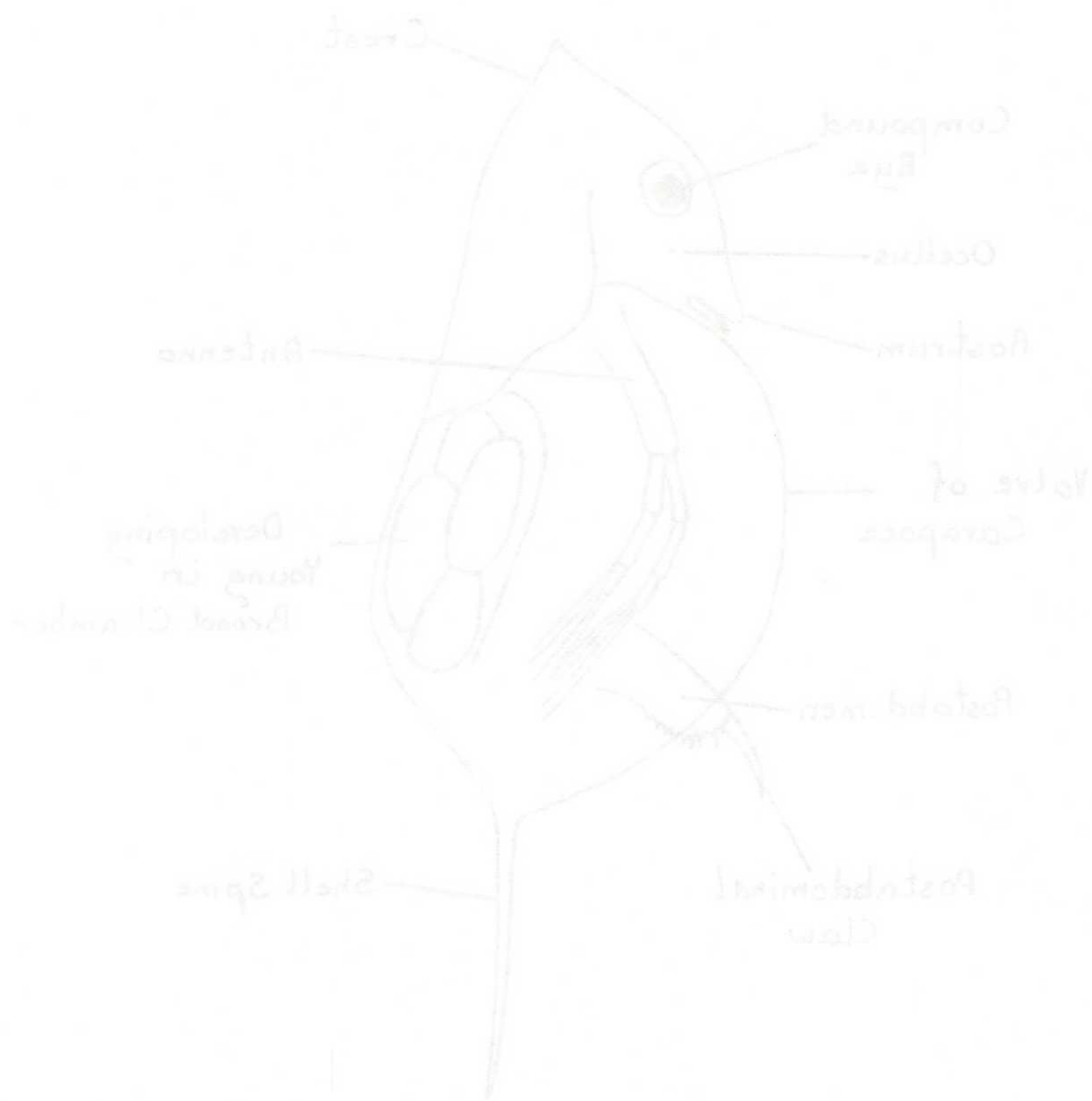
(b) Cyclopoid
40-100x



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Figure 9. General morphology of a Daphnid.





1. The first of the three questions is:

What is the

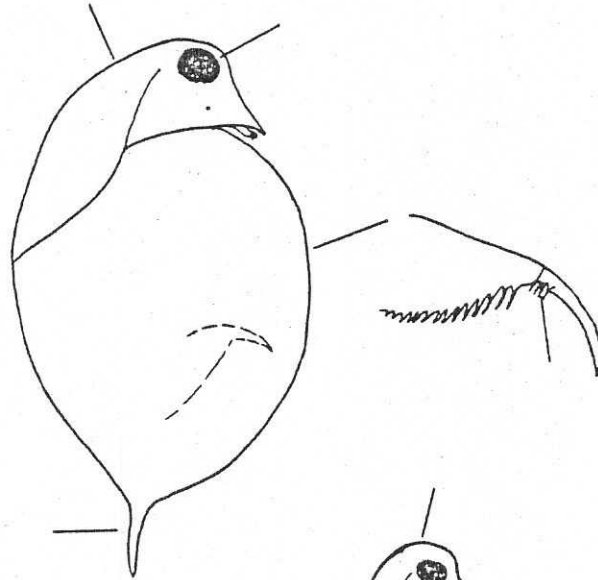
second question?

What is the

third question?

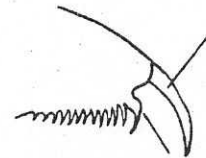
Figure 10. Key features of the three dominant Daphnid species of Sunfish Lake.

- a) *D. pulex*
- b) *D. rosea*
- c) *D. schoedleri*

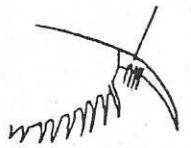
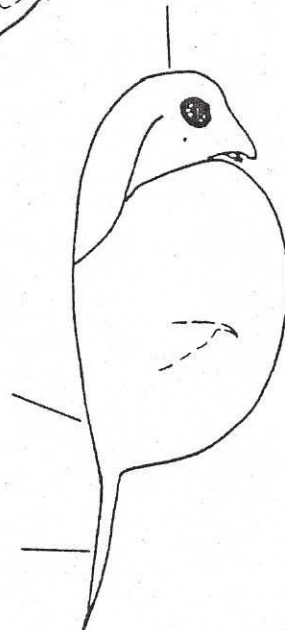


(a) *D. pulex*
50 x

(b) *D. rosea*
30 x



(c) *D. schoedleri*
50 x



Salmon 7-23



Salmon 7-23



Salmon 7-23



RESULTS

Table 2. Summary of population data: July-November, 1950

All values given, represent numbers

per litter.

W₁: Mean number of eggs per ova

W₂: Mean number of larvae per female

W₃: Number of females carrying

Table 2. Seasonal summary of zooplankton data; July-November, 1980

- All values given, represent numbers
per litre.

M#E/S: Mean number of eggs per sac

M#L/♀: Mean number of larva per female

#♀'s C: Number of females carrying

	1st July	July 18	July 26	Aug. 2	Aug. 8	Aug. 15	Aug. 22	Aug. 30	Oct 4	Nov. 25
Calanoid	1.07	24.34	24.86	22.40	20.89	21.07	21.28	24.00	15.19	4.20
M#E/S	9.5	8.09	6.7	5.5	6.07	5.85	5.29	5.25	--	--
# of Sacs	0.01	1.20	0.38	0.35	0.31	0.32	0.19	0.13	--	--
Cyclopod	0.03	1.36	2.26	3.96	3.45	7.81	4.55	5.54	3.11	1.10
# ♀'s C.	--	--	--	--	--	--	--	0.02	--	0.14
Naupli	0.18	19.11	18.32	13.45	17.84	8.26	12.55	9.89	9.37	8.25
<i>K. longispina</i>	9.73	12.94	20.53	18.18	20.11	22.64	24.35	17.20	3.47	0.46
<i>K. bostoniesis</i>	3.38	30.80	73.35	85.23	41.36	63.68	135.9	141.95	72.49	36.96
<i>F. longiseta</i>	2.73	36.17	81.38	96.67	131.4	55.03	183.3	134.68	22.50	1.12
<i>K. quadrata</i>	0.08	0.30	0.78	6.14	1.69	1.52	2.48	3.08	3.48	0.07
<i>Ke-ella</i> sp.	0.13	2.56	0.51	0.46	0.86	0.44	0.03	0.34	0.73	0.02
<i>D. rosea</i>	3.06	1.36	0.92	1.38	2.04	4.38	2.04	1.59	1.35	0.03
M#L/♀	1.45	1.45	1.46	1.07	1.22	1.32	1.16	1.14	115	--
# ♀'s C.	0.68	0.58	0.35	0.61	0.92	2.61	0.71	0.46	4.68	
<i>D. pulex</i>	0.65	0.93	1.22	0.31	0.49	0.22	0.46	0.78	0.55	0.19
M#L/♀	1.75	1.5	2.85	2.67	4.75	1.5	5.08	4.9	3.24	2.85
# ♀'s C	0.04	0.08	0.78	0.13	0.27	0.14	0.38	0.53	0.31	0.12
<i>D. retrocurva</i>	0.01	0.04	0.02	0.01	0.03	0.03	0.01	0.01	--	0.01
<i>D. schoedleri</i>	0.67	0.44	0.27	0.38	0.71	1.62	1.07	0.79	1.26	0.19

STATION	DATE	TIME	WIND	TEMP	REL. HUM.	SEA	REMARKS
1	10/10	0800	10	25.0	75	1	Light breeze
2	10/10	0900	12	26.0	70	1	Light breeze
3	10/10	1000	15	27.0	65	1	Light breeze
4	10/10	1100	18	28.0	60	1	Light breeze
5	10/10	1200	20	29.0	55	1	Light breeze
6	10/10	1300	22	30.0	50	1	Light breeze
7	10/10	1400	25	31.0	45	1	Light breeze
8	10/10	1500	28	32.0	40	1	Light breeze
9	10/10	1600	30	33.0	35	1	Light breeze
10	10/10	1700	32	34.0	30	1	Light breeze
11	10/10	1800	35	35.0	25	1	Light breeze
12	10/10	1900	38	36.0	20	1	Light breeze
13	10/10	2000	40	37.0	15	1	Light breeze
14	10/10	2100	42	38.0	10	1	Light breeze
15	10/10	2200	45	39.0	5	1	Light breeze
16	10/10	2300	48	40.0	0	1	Light breeze
17	10/10	0000	50	41.0	0	1	Light breeze
18	10/10	0100	52	42.0	0	1	Light breeze
19	10/10	0200	55	43.0	0	1	Light breeze
20	10/10	0300	58	44.0	0	1	Light breeze
21	10/10	0400	60	45.0	0	1	Light breeze
22	10/10	0500	62	46.0	0	1	Light breeze
23	10/10	0600	65	47.0	0	1	Light breeze
24	10/10	0700	68	48.0	0	1	Light breeze
25	10/10	0800	70	49.0	0	1	Light breeze
26	10/10	0900	72	50.0	0	1	Light breeze
27	10/10	1000	75	51.0	0	1	Light breeze
28	10/10	1100	78	52.0	0	1	Light breeze
29	10/10	1200	80	53.0	0	1	Light breeze
30	10/10	1300	82	54.0	0	1	Light breeze
31	10/10	1400	85	55.0	0	1	Light breeze
32	10/10	1500	88	56.0	0	1	Light breeze
33	10/10	1600	90	57.0	0	1	Light breeze
34	10/10	1700	92	58.0	0	1	Light breeze
35	10/10	1800	95	59.0	0	1	Light breeze
36	10/10	1900	98	60.0	0	1	Light breeze
37	10/10	2000	100	61.0	0	1	Light breeze
38	10/10	2100	102	62.0	0	1	Light breeze
39	10/10	2200	105	63.0	0	1	Light breeze
40	10/10	2300	108	64.0	0	1	Light breeze
41	10/10	0000	110	65.0	0	1	Light breeze
42	10/10	0100	112	66.0	0	1	Light breeze
43	10/10	0200	115	67.0	0	1	Light breeze
44	10/10	0300	118	68.0	0	1	Light breeze
45	10/10	0400	120	69.0	0	1	Light breeze
46	10/10	0500	122	70.0	0	1	Light breeze
47	10/10	0600	125	71.0	0	1	Light breeze
48	10/10	0700	128	72.0	0	1	Light breeze
49	10/10	0800	130	73.0	0	1	Light breeze
50	10/10	0900	132	74.0	0	1	Light breeze

TABLE 2 (Cont'd)

	1st Wk July	July 18	July 26	Aug. 2	Aug. 8	Aug. 15	Aug. 22	Aug. 30	Oct. 4	Nov. 25
<i>♂ daphnia</i>	--	--	--	--	--	--	--	0.01	0.35	--
Juvenile dap.	0.78	2.96	4.23	3.48	4.55	3.19	7.32	5.11	3.25	0.88
loose D.L.	2.39	2.86	0.78	0.75	0.65	1.55	0.98	0.86	0.29	--
<i>B. ooregoni</i>	0.06	0.48	0.23	0.33	0.57	0.78	0.25	0.18	0.04	--
<i>D. leuchtenber.</i>	--	--	0.01	0.11	0.28	0.33	0.18	0.13	0.39	--
Ostracoda	--	0.01	0.01	0.03	--	0.04	0.01	0.05	0.01	--

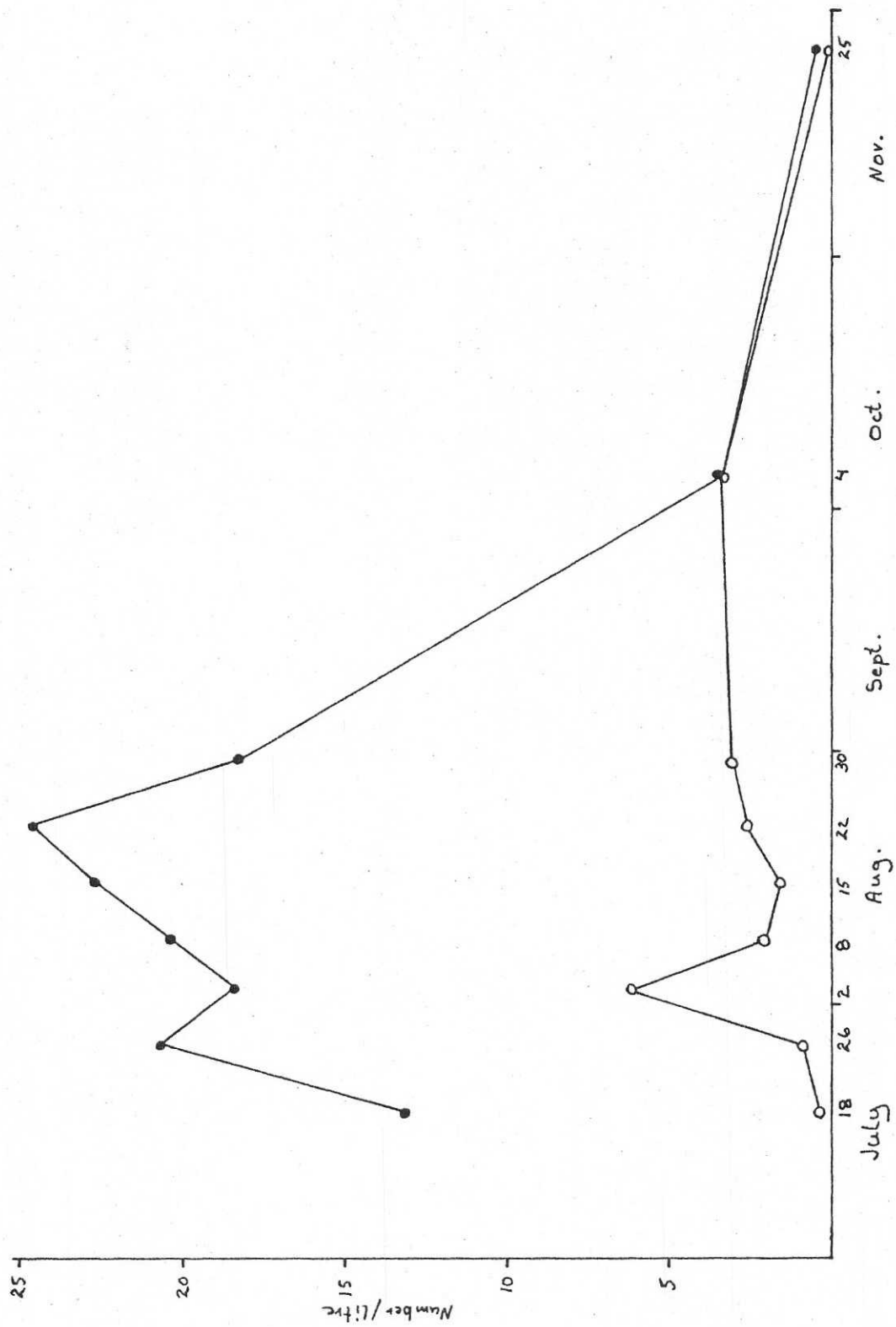
Trace Rotifers: *F. opoliensis*
F. terminalis
Filina sp.
Trichocera sp.
Philodina sp.

The following information is provided for your information only. It is not intended to be used as a basis for any decision. The information is provided for your information only. It is not intended to be used as a basis for any decision.

Figure 11. Seasonal distribution of

● *Kellicottia longispina*

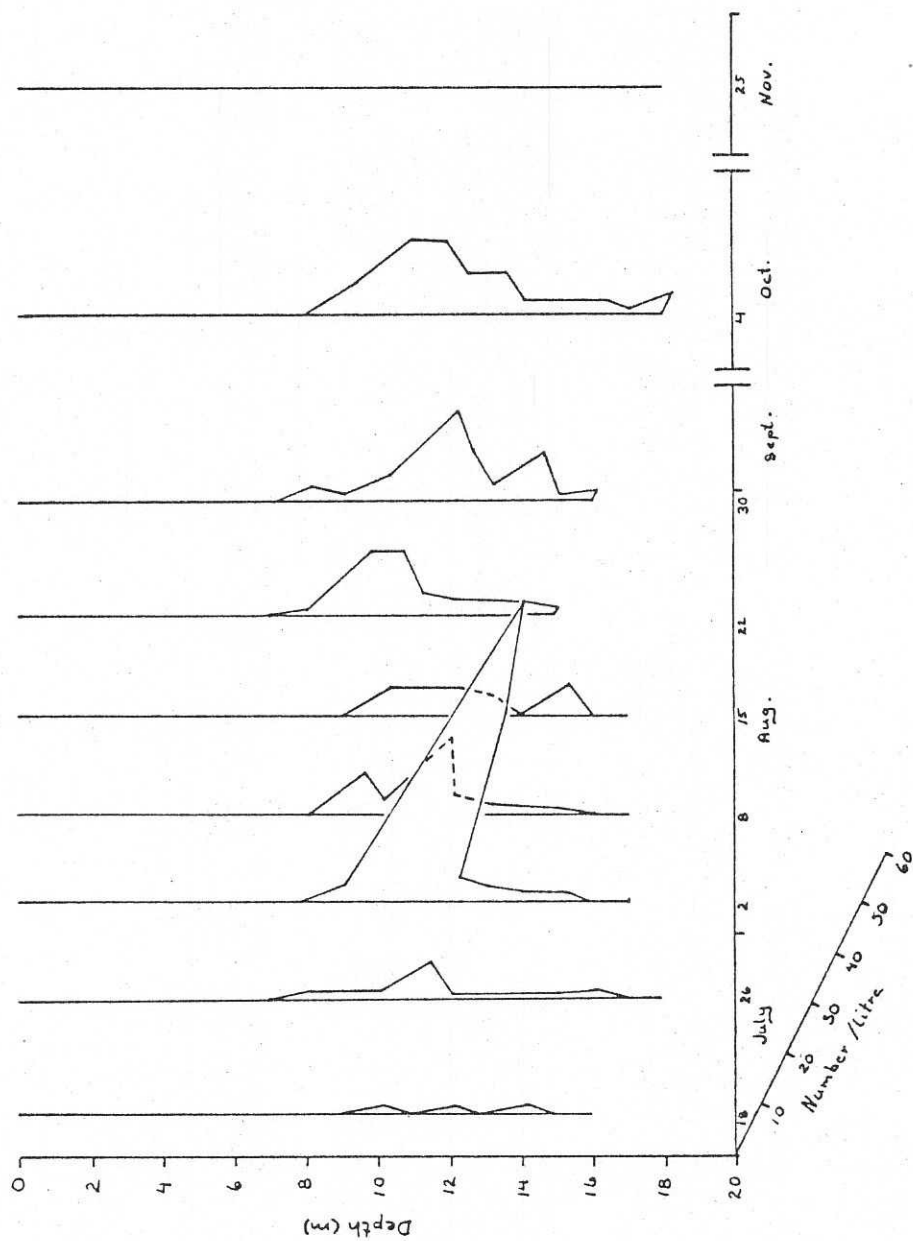
○ *Keratella quadrata*





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Figure 12. Vertical distribution of *Keratella quadrata*.



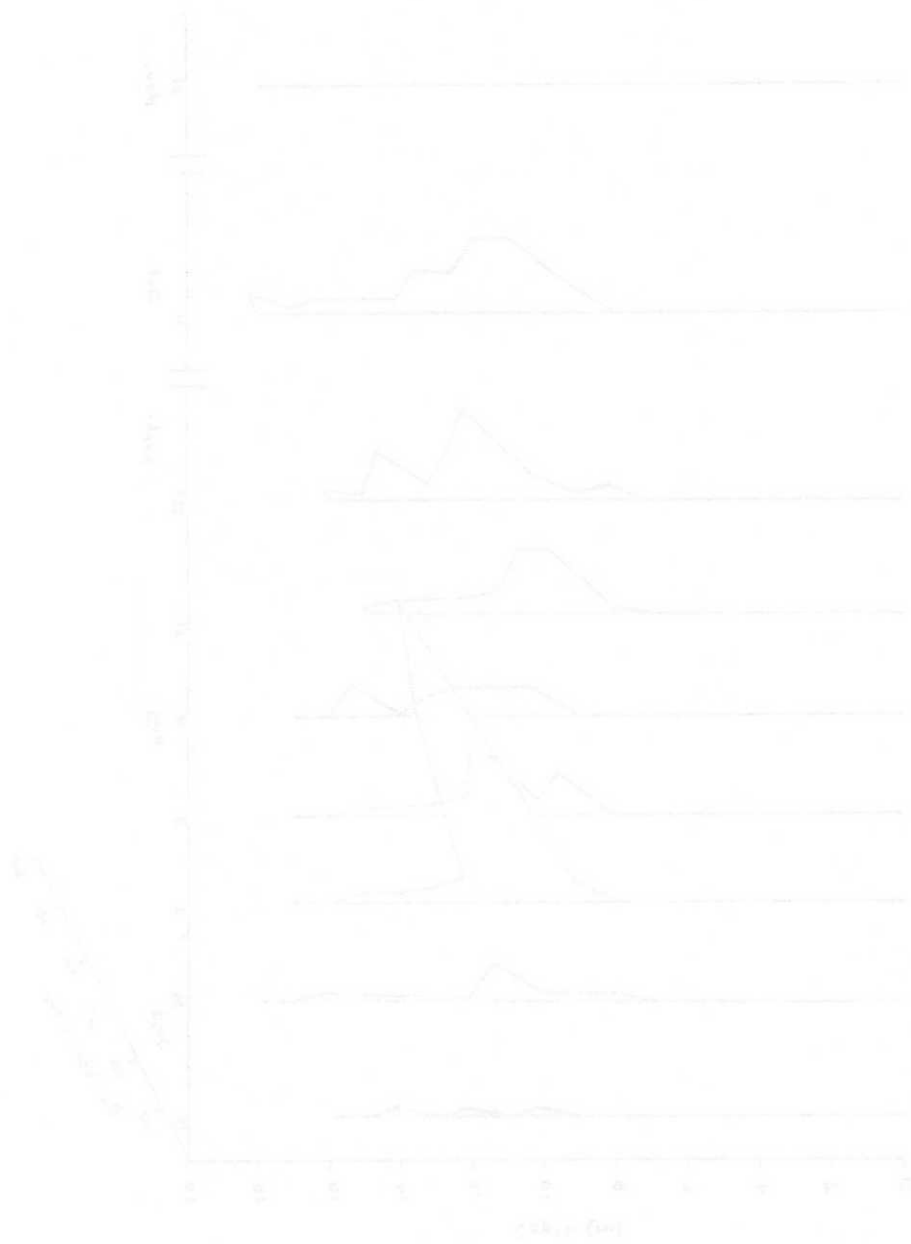
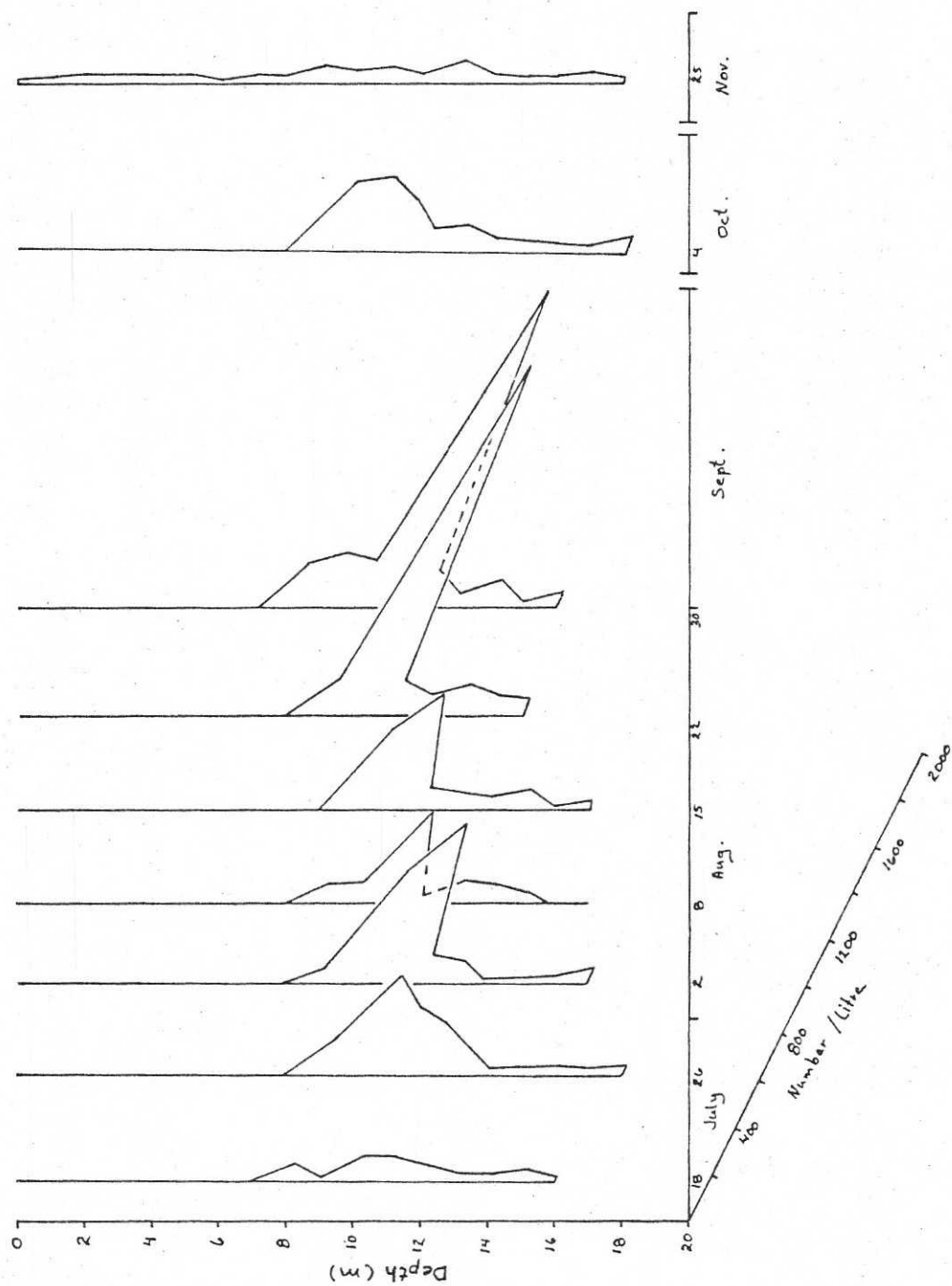


Figure 13. General distribution of *Salmonella* *h* serotype.

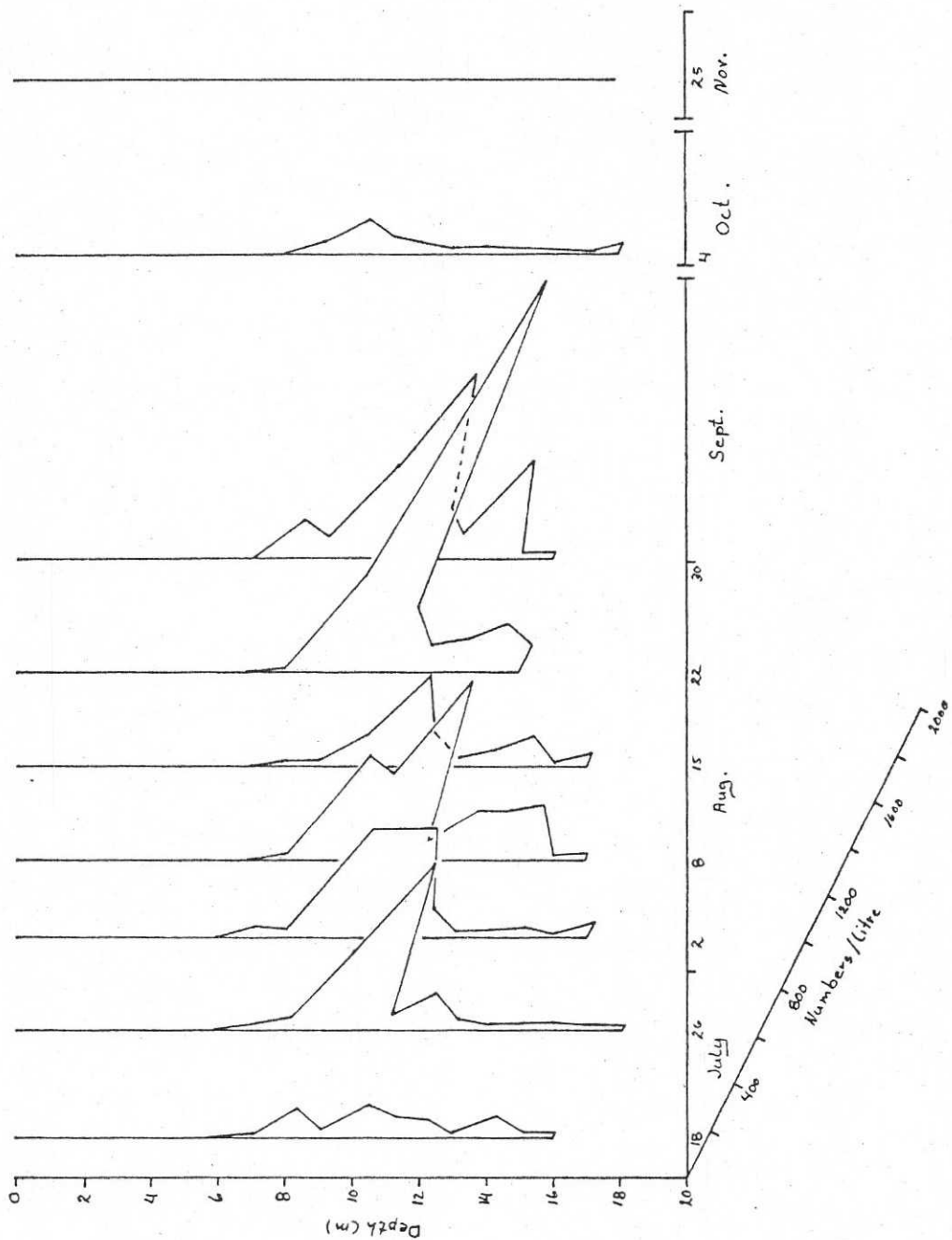
Figure 13. Vertical distribution of *Kellicottia bostoniensis*.





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Figure 14. Vertical distribution of *Filina longiseta*.

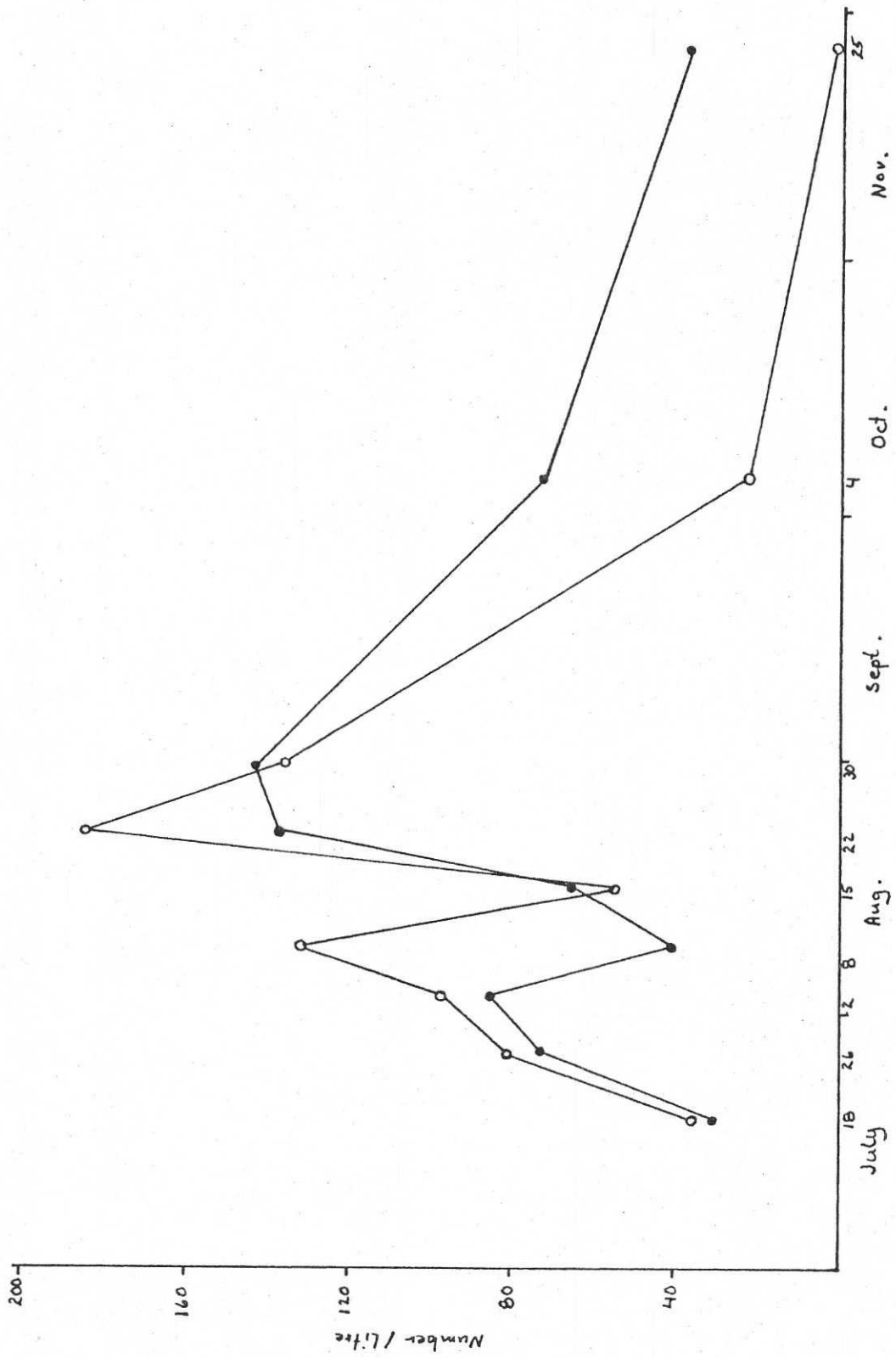


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Figure 15. Seasonal distribution of

● *Kellicottia bostoniensis*

○ *Filina longiseta*



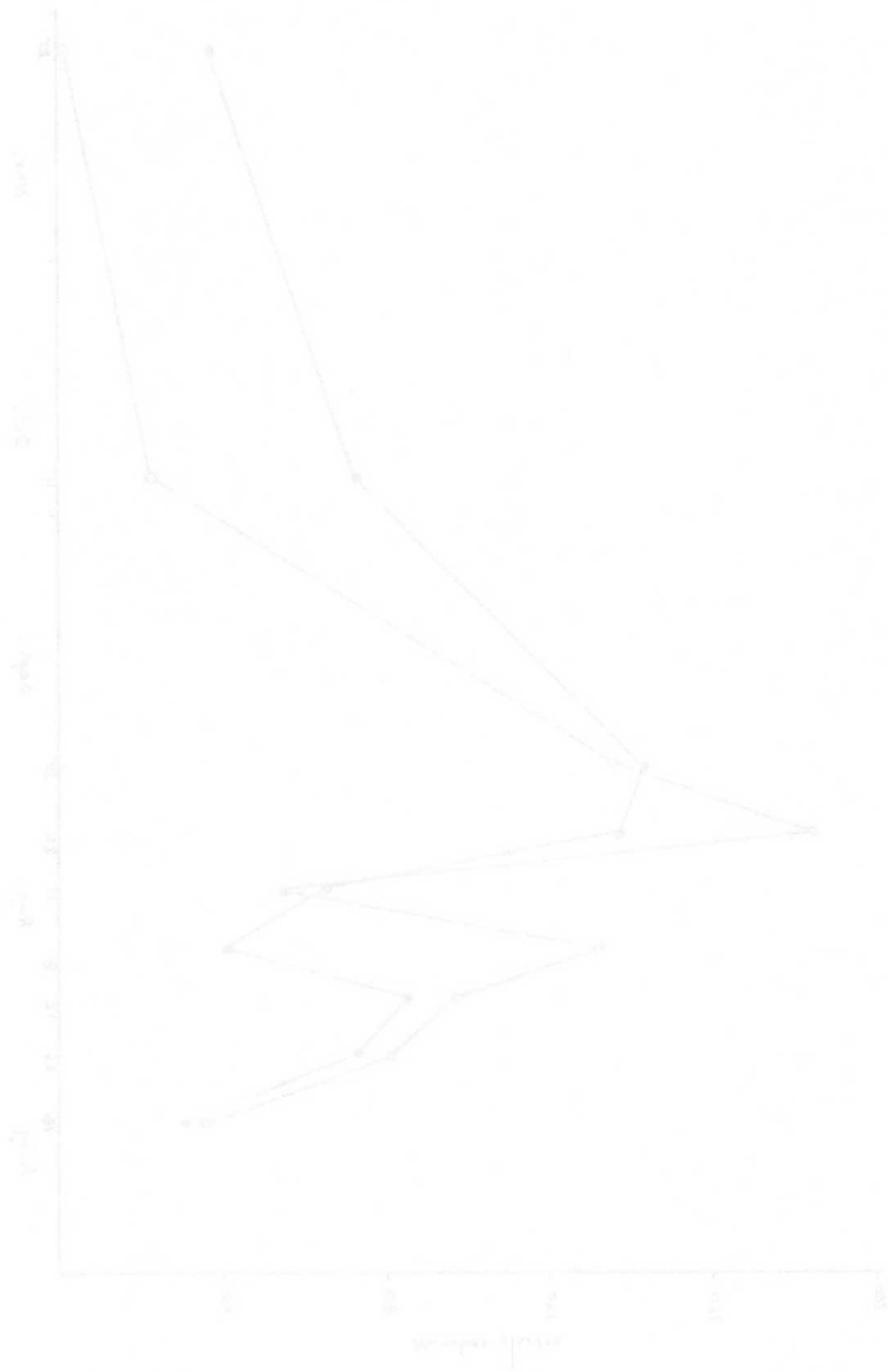
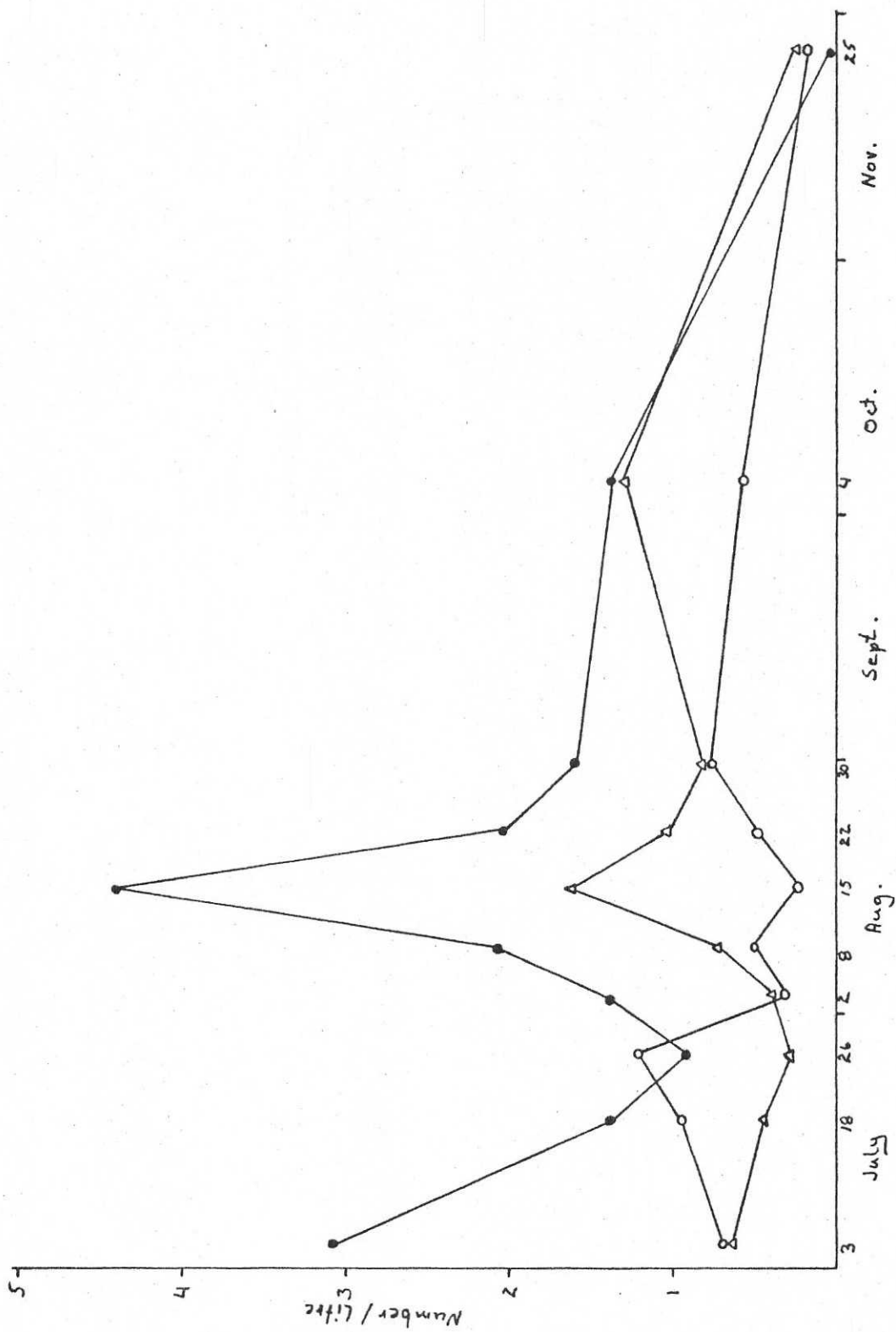


Figure 16. Seasonal distribution of

- *Daphnia rosea*
- *D. pulex*
- △ *D. schoedleri*



20/10



1. The first of these is the

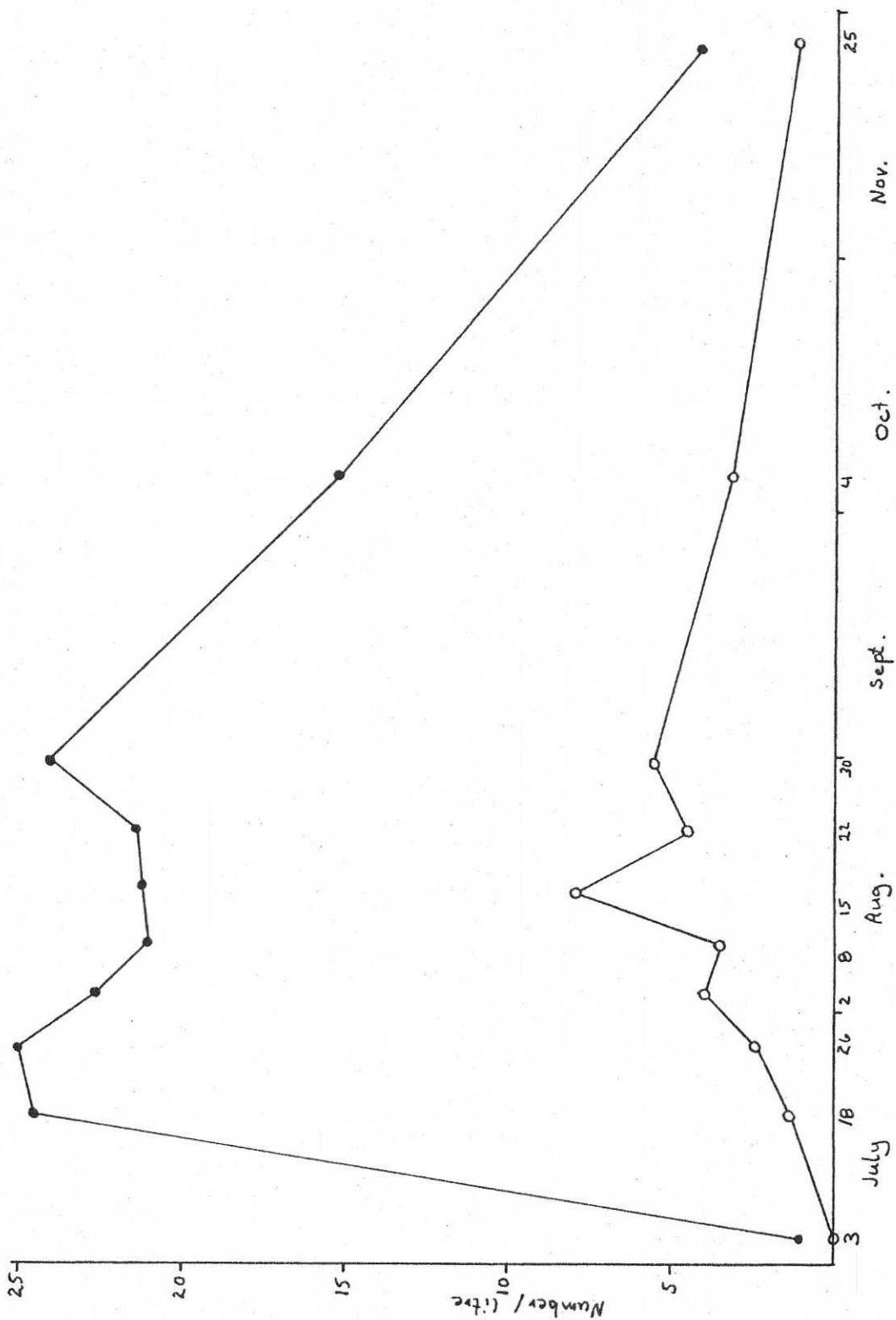
the second is the

the third is the

Figure 17. Seasonal distribution of

● Calanoids

○ Cyclopoids





DISCUSSION

Diurnal migration of zooplankton through the water column is a well documented phenomenon (Pennak, 1944; Plew and Pennak, 1949; Glen, 1971). Because of this diurnal migration, analysis of the zooplankton data will be restricted mainly to seasonal variation, as migration patterns result in a daily flux of zooplankton distribution with depth. However, three of the four major rotifer species; *K. bostoniesis*, *F. longiseta*, and *K. quadrata* all show little or no diurnal migration, enabling some depth distribution analysis.

A coarse mesh size was used to collect the zooplankton on the initial sampling date, thus impairing proper collection of the micro-zooplankton (rotifers and nauplii). A finer mesh size was employed for the remaining sampling periods, allowing for a proper investigation into the rotifer distributions.

The rotifer composition of Sunfish Lake was previously documented by George and Fernando (1970). The emphasis of their study was on seasonal changes in diurnal migration patterns of three species of rotifers; *K. quadrata*, *Polysarthra vulgaris*, and *Filina terminalis*. At the time of their study (1967), these three species were observed to be the dominant rotifer species in Sunfish Lake. It would appear that the rotifer composition has changed considerably in the twelve years since George and Fernando carried out their study. *F. terminalis*, currently, is found only in trace quantities, and *P. vulgaris* seems to have disappeared completely for the duration of the sampling period.

(table 2). In their study of the Sunfish Lake rotifers, George and Fernando made note of maximum population densities for July and August of the dominant rotifers they encountered; the two months correspond with this thesis' study period. Interestingly enough, if the maximum values corresponding to July and August from their migration study, are added and compared to the same maximum values attained from this thesis using the four currently dominant rotifer species, similar values are observed. In the 1967 study, the maximum average for the two months was 293.5 rotifers per litre, whereas in the 1979 study, the average was 267.5 rotifers per litre. These values are probably not significantly different. It should be noted, that this statistic does not allow for the impact of trace species populations, or variation in population fluxes between the two studies. Still, it is the best means for comparison with the available data. While the exact change in populations cannot be determined, a statement implying that the rotifer populations have changed little numerically in the past twelve years has some support. All three of the dominant 1967 rotifer species were restricted to the hypolimnion during the summer months as were the dominant rotifers found in the 1979 study, with the exception of *K. longispina*. Why the change in species composition, without an associated numerical change? Perhaps a change in composition not quantity of available food items, like algae or bacteria, or a chemical change such as a dissolved oxygen flux. The possibilities are numerous and elude a decisive answer. What does seem certain, is a major occurrence has taken place, gradually or spontaneously, over the past twelve years and is reflected in a change in rotifer composition. One

other possibility, not to be overlooked, is the possible existence of long term cycling, perhaps related to periodic overturning of the monimolimnion.

George and Fernando noted the existence of diurnal migration in Sunfish Lake rotifers. Because the mean distance travelled by these rotifers was consistently short, being approximately 2 m, it seems reasonable to carry out a vertical distribution analyses into the Sunfish Lake rotifer populations.

K. longispina was patchily distributed throughout the water column (appendix 1-10). This may be in response to the distribution of its preferred food item, *Cryptomonas* (Hutchison, 1967), which is also distributed throughout the water column of Sunfish Lake (Hamilton, 1980). *K. longispina* (fig. 11) maintains relatively abundant summer populations with a peak in mid-August. This is followed by a steady decline to trace levels in late November. No clear correlation was found between the seasonal distribution of *K. longispina* and Hamilton's data on the seasonal distribution of phytoplankton. Edmondson (1964) proposed that some rotifer specie populations may be temperature dependent. Perhaps *K. longispina* is one such specie. This would explain the lack of any distinct correlation between *K. longispina* and the various algal populations. It is however, doubtful that one such parameter will successfully model this population, rather several factors must be considered.

K. quadrata appears restricted to the hypolimnion (fig. 12), this restriction was also noted by George and Fernando (1970). Within the hypolimnion, the depth of maximum population density may fluctuate between 9 m and 10 m; most likely due to the nature of the verticle

migration discussed earlier. The seasonal maxima, found early in August (fig. 11), is similar to that found by George and Fernando, however since their 1967 study, the population has dropped by almost twenty-fold.

The remaining two, and by far the most abundant rotifer species, are *K. bostoniesis* and *F. longiseta*. They both follow similar spatial (fig. 13 and 14) and seasonal (fig. 15) distributions, reflected not only in the patterns of the distribution, but also by their similar numerical responses.

Both species start off in mid-July with similar population sizes. Rapid population growth is experienced by both species, with *K. bostoniesis* reaching its first seasonal peak at the beginning of August; *F. longiseta* peaking a week later but with a higher value. Both populations immediately drop following their peaks and then rapidly return for a second and even higher peak. Again *F. longiseta* has the higher peak, but this time *K. bostoniesis*, peaking at the end of August, is a week later than *F. longiseta*. Entering the fall, both species undergo drastic population reductions, until at the end of November, when *F. longiseta* is almost non-existent, and *K. bostoniesis* has returned to its mid-July population level.

Of particular interest, is the seasonal distribution of the tentatively identified green algae, R.S. (Hamilton, 1980). Like the two rotifers just previously mentioned, R.S. displays two seasonal peaks approximating those of *K. bostoniesis* and *F. longiseta*; one early in August and a second, higher peak in mid to late August. Further enhancing this correlation, is the observed vertical distributions. R.S. displays

a distinct maxima throughout the summer at 11 m, similarly, the two rotifer species both peak between 10 m and 11 m.

The precise cause(s) of this correlation is not clear. R.S., a small round green algae, clumped into various group sizes (fig. 6c) would seem to be a very manageable food item. It must be noted, though, that both *F. longiseta* and *K. bostoniensis* show a greater range in their depth distributions than does R.S. It is possible that bacterial populations, associated with R.S. and some of the hypolimnetic blue green algae, like *Oscillatoria aghardii* also influence the growth of these two rotifers. Because the depth distribution patterns of these two rotifers, maintain a fairly constant configuration throughout the season, the influence of diurnal migration of the spatial distribution can be taken as minimal. This would no doubt, need verification through a field investigation.

The most abundant cladocera, *D. rosea*, undergoes a decline from the start to the end of July (fig. 16). A second peak follows in mid-August. The decline which follows is at first very steep, the rate of decline, does however slow down from the end of August to the end of November.

The distribution of *D. schoedleri* (fig. 16) shows a similar seasonal pattern to that described by Wright (1965). The first mid-August peak coincides with *D. rosea*'s mid-August peak. However, while *D. rosea* is undergoing a decline in early October, *D. schoedleri* experiences a second peak, followed by a decline.

D. pulex also showed two peaks during the sampling period (fig. 16). Its first peak occurs at the end of July, corresponding to the minimas

observed for both *D. rosea* and *D. schoedler* at this time of year.

D. pulex's second peak, occurring at the end of August, also corresponds to lows in the populations of the other two daphnid species.

The abundance of all three daphnid species is low at the end of November. The appearance of male daphnias in the fall may suggest a switch from their summer reproductive strategy by parthenogenesis, possibly to a short sexual cycle involving the production of thick resting eggs, termed ephippial eggs (Hutchinson, 1967). Whether or not this switch in reproductive cycles actually takes place is unknown, as the ephippial eggs were never actually observed in the Sunfish Lake daphnia. The acquisition and analysis of spring and early summer samples, would add greatly to the understanding of seasonal strategies taken by these three species in Sunfish Lake.

Reference to previous existing populations of cladocera and copepods in Sunfish Lake, is limited to Brandlova et al's (1972) acknowledgment of the existence of *D. rosea* and *Daphnia retrocurva* in this lake. This restricts the scope of the following discussion to a comparison of existing literature with the observed trends found in Sunfish Lake.

The three dominant cladocera found; *D. rosea*, *D. schoedleri* and *D. pulex*, are all large specimens. When these populations are compared with other studies, the actual size of the populations seem to be quite small for a mesotrophic lake (Hamilton, 1980). In fact, when the daphnid populations of Sunfish Lake were compared to those investigated by Glen (1971) in Little Round Lake, a lake later determined as being oligotrophic (Munro, 1978), very comparable population sizes are observed. One would intuitively expect the mesotrophic lake to yield larger

populations than a less productive oligotrophic lake. Wright (1965) provides further support suggesting that Sunfish Lake daphnia populations are small, from his study on *Daphnia* populations in Canyon Ferry Reservoir, Montana. Wright found *Daphnia galeata* and *D. schoedleri* to be the dominant daphnia in his study. Their combined populations are approximately five-fold greater than the Sunfish Lake populations. Hall et al (1976) explains such low populations in his Size-Efficiency hypothesis. Hall points out that larger zooplankton compete with the smaller species for the same, fine particulate matter. The larger zooplankton, however, feed more efficiently than the smaller ones and can also prey on larger particles. Hall's conclusion is, that under low predation pressures, larger zooplankton species will be favoured, but as predation increases, the larger zooplankton will be selectively preyed upon, thus favouring the smaller species like the rotifers and some of the small copepods. Goldman et al (1979) develop this idea even further. In a study on Lake Tahoe, California-Nevada, he acknowledges the fact that the kakanee salmon, *Oncorhynchus nerka* and the opossum shrimp, *Mysis relicta* selectively prey on the larger daphnia species, thus increasing the daphnid mortality rate. The failure of the larger daphnia to recover, after depletion to near removal of the two previously mentioned predators, indicated to Goldman that the change in algal composition observed may have led to a decreased birth rate in the large zooplankton.

In short, selective predation, and a shift in algal composition, can have a profound effect on the zooplankton composition. For Sunfish Lake, a study on the diet of the lake's fishes would be warranted to assess the possible effects of such predation.

predation than a less predictable oligotrophic lake (Wetzel 1983).
provided further support suggesting that predation does regulate zooplankton
there was still, there was strong evidence for predation in Lake Ontario
Boschma, 1982. They found that the predation and the abundance of
is the dominant factor in his study. Their results are consistent with
approximately 10-fold greater than the 10-fold lake population, but
at 1982 predation was not significant in his 1982-1983 study. This
factor. He found that the larger zooplankton species with the
smaller species for the same, this particular species. The larger
zooplankton, however, feed more efficiently than the smaller ones and
also prey on larger species. He found that the 10-fold lake population
the predation pressure larger zooplankton species will be reduced
but the predation pressure, the larger zooplankton will be reduced
predation, this is because the smaller species are the most vulnerable
one of the small species, and even at 1982, this is
even further. In a study on Lake Ontario, Wetzel (1983) found that
before the 10-fold lake, the 10-fold lake, the 10-fold lake, the 10-fold lake,
zooplankton, which is not necessarily true on the larger lake.
species, the larger the zooplankton, the larger the species. The 10-fold lake
larger species is reduced, after predation is removed, the removal of the
zooplankton population, indicated to Wetzel that the removal of the
that predation observed may have led to a reduced birth rate in
the large zooplankton.
In short, evidence for predation, and a shift in the zooplankton
have a strong effect on the zooplankton community. For example, the
a shift in the lake's food web would be expected to affect the
predation pressure on the zooplankton.

This thesis attempted an indirect determination of the predation rate through an estimation of the natality rate found in the daphnids. It was intended to use the same methodology outlined by Wright (1965) who modified his method from Hall (1964). By knowing: the number of eggs in the population (E), determined through observation; the duration of the egg and embryonic stages (D), approximated from previously determined values of similar species (Wright, 1965; Hall, 1964), and the initial population size (No), the number of new born per individual per day (B) can be calculated as follows:

$$B = \frac{E}{D N_o}$$

Once B has been determined the instantaneous birth rate (b) can be estimated from the following expression:

$$e^b = 1 + B$$

The next step is to calculate the average instantaneous rate of population change (r) from the following equation:

$$N_t = N_o e^{rt}$$

Where No is the initial population size; N_t is the population after time t.

Knowing b and r, the mortality rate, d can be determined as follows:

$$r = b - d$$

The main assumption to be made is that mortality results primarily from predation. Wright (1965) provides some evidence that this assumption is based on sound reasoning. He compared the mortality rate of *D. schoedleri* with population levels of *Leptodora kindtii*, a major predator, and found a very strong correlation between *L. kindtii* population levels and the mortality rate. Unfortunately, during preservation

of the zooplankton samples, the daphnia had a tendency to burst open and release their larva. While the number of loose daphnia larva was recorded, it was unknown what species the larva represented, or whether the daphnia released all or only some of the larva.

Due to the difficulty in identifying the Copepods, identifications were only taken to suborder. This limited identification, essentially obscures any seasonal trends which may have been displayed by various copepod species.

The calanoids greatly outnumber the cyclopoids by almost five-fold. The calanoids undergo an extremely sharp population growth at the start of July, this level is maintained to the end of August, at which point a continual decline is experienced through to the end of November (fig. 17). The cyclopoids experience a much slower growth rate than the calanoids do. Their peak in mid-August is followed by a gradual decline to the end of November (fig. 17).

A more detailed identification of the copepods may reveal some interesting trends between the copepods, cladoceras, and algal populations. One general trend was noted by Dr. Watson (unpublished) in a seminar given at Queen's University, February, 1980. In his study of the interrelationships of zooplankton and phytoplankton formed in Lake Superior, it was discovered that the overall zooplankton biomass was directly proportional to the lake temperature. While this thesis gives no measure of zooplankton biomass, the summer maximas and fall minimas displayed by the Sunfish Lake zooplankton, are consistent with Dr. Watson's observations.

The seasonal succession observed in the zooplankton of Sunfish Lake, reflects a continually changing environment within the ecosystem. This thesis, along with other studies, do not provide clear-cut, cause and effect explanations for the observed trends. They do however, emphasize parameters which may alone or in combination with other parameters, determine which zooplankton species will be dominant at a particular time of year. Such parameters may include: changes in algal composition, temperature fluxuations, predation pressures, strategies employed by the organism, and chemical variables. Because of the complexity of limnological interactions, it is doubtful that a simple explanation will reveal the driving forces behind the succession. More likely, the answers will only surface after further research and the integration of a wide array of existing knowledge.

Having shown the seasonal trends currently active in Sunfish Lake, the next step in the program, would be to fill in the zooplankton data from April to June, and further the copepod identifications to species. This study would probably be followed by a dietary analysis of the Sunfish Lake fishes. At this point the importance of benthic and littoral zone communities could be determined and investigated if desired.

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Corrections to the Bibliography, page 54:

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